Report of the

Senior Review of

Origins and Structure and Evolution of the Universe

MISSION OPERATIONS AND DATA ANALYSIS (MO&DA) PROGRAMS

August 11-13, 1998

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Introduction

The Astrophysics Senior Review panel met August 11-13, 1998 to review requests from eight missions for additional MO&DA funding in the FY99-FY02 time frame. The program is facing the most serious funding problem yet considered in such reviews, since the total of the minimal requests from each mission for the first time exceeded the available funds. In addition, we were considering missions in a variety of stages: one was not launched yet but has a very short mission life (WIRE), one was no longer operating (ISO), two were still in their prime phases (VSOP and WIRE), and most of those operating were technically compromised in one way or another. The panel was therefore faced with the task of recommending some very difficult decisions.

In assessing the scientific merit of each mission, the Review panel used the newly-released OSS Strategic Plan as a balanced guide to important problems in current research. Panel members were carefully chosen to provide expertise over a broad range of fields, including, for the first time, solar physics so as to assess the importance of CGRO to that field. Factors which the panel considered in judging scientific merit included relevance to NASA OSS goals, expected impact of the future science program, the discovery potential and uniqueness of the mission, the breadth of science addressed, the breadth of the astronomical community directly involved as PI teams or Guest Investigators, the importance of mission capabilities to other missions, and the value of the archive for continuing research. Secondary factors included the quality of the education and public outreach activities, and the impact on technology advancement. Overall, we considered these eight missions in the context of all opportunities that are available or currently anticipated for space research.

The Panel was asked to assess scientific cost effectiveness, i.e., science value per dollar. To accomplish this, the panel took into consideration the scientific merit as evaluated according to the above criteria, and the full cost to the NASA Office of Space Science (OSS) of extended mission operations, including the cost of science operations centers. This was necessary to put VSOP and ISO on a more nearly comparable basis to the other missions, since some of their OSS operations costs are carried in separate budgets. The panel recommends that this process be followed in future reviews.

General Policy Recommendations

1. Scope of Charge

This Senior Review panel shares the concern expressed by the previous two Senior Reviews that there is no peer forum in which to examine and make recommendations regarding the scientific effectiveness of the allocation of resources among the LTSA, ADP, and ATP programs as well as the mission-specific operations and grants budgets. This panel also shares the view that the major observatory missions now flying or to be launched in the next few years, HST, AXAF, and SIRTF, should also be subject to review for effective use of resources. As more missions are operating and more archival data become available, it is critical that the community use its limited resources most productively. We agree with the previous panels that the Senior Review is the appropriate forum to consider these issues.

We recognize that reviewing all of these matters at each Senior Review would be a prohibitively large task for a single review group, and that revisions in program aims on two-year time scales would in any event be more disruptive than helpful, and would not allow adequate time for re-evaluation. We therefore recommend that reviews of all of the large observatory programs be carried out as part of the Senior Review process every fourth year, and that the balance among LTSA, ADP, and ATP and mission operations budgets be considered as part of the Senior Reviews in the alternate years, i.e., also on a four-year time scale. Separation of these functions will allow fine-tuning of the panel membership to best support each purpose. We believe that the review process should be lengthened by no more than one day to accomplish these new purposes.

We recommend that the appropriate time to begin the reviews of HST, AXAF, and SIRTF would be in the 2002 Senior Review, since all will then be operating and HST will be approaching its final planned servicing mission. Definition of materials to be provided by these missions should be considered at the 2000 Senior Review. We recommend that the first review of the LTSA, ADP, and ATP programs be included in the 2000 Senior Review. For that review, panelists should be provided in advance with program information such as total funding in each element, titles of the grants funded, notable scientific results, over-subscription rates (in proposals and funds), publication rates, utilization of data from the various missions, statistical information on grant duration and renewals, turn-over of awardees, and multiple awards to individual PI's, and any other metrics considered relevant to each program. We suggest that time should be provided at the Senior Review for an advocate for each of these programs to summarize the program and answer questions.

2. Data Analysis Funding by the Astrophysics Data Program (ADP)

For PI-class missions beyond their prime phases, the Senior Review strongly supports the concept of providing grant support for analysis of new observations through competitive proposals to the

Astrophysics Data Program (ADP). ADP grants allow funding for more comprehensive scientific investigations than single mission observing grants, and a common, science-based peer review will assure that the best science is accomplished with the limited available resources. Where necessary, Projects in their extended mission phase are encouraged to provide minimal direct support to observers for expenses, e.g., page charges, even though grant funding is not provided by the Project. Instrument teams on such missions should continue to receive data analysis support from the Project for analysis of new observations as long as they are responsible for support of instrument operations.
Instrument teams may propose to the ADP for archival research projects.

3. Data Formats

The Senior Review encourages NASA to require future missions, including collaborative projects that involve foreign partners, to comply with data format standards adopted by the astronomical community.

4. NASA OSS Strategic Plan

A new feature of this Senior Review was the request that proposers demonstrate the relationship of their scientific programs to the aims of the recently-released NASA OSS Strategic Plan. Following the review, the Review team was asked to comment on whether this mapping was found to be scientifically useful, and whether it was procedurally constructive.

The Review team has concluded that the answer to both of these questions is a qualified “yes”: there is value to the review process in making this connection between mission plans and Agency objectives. The panel is asked to judge relative scientific value of widely disparate studies. In making these judgments, we considered, among other things both the scientific importance of what we believed the mission would accomplish and the scientific breadth of those contributions.

Individual panelists have their own sense of what problems they consider important, usually reflecting their own objectives, and the Strategic Plan provides a balanced framework in which to make those evaluations. One could argue that the Strategic Plan is so broadly stated that almost any astronomical investigation can find a place there, but the emphasis on central questions does provide some help in deciding which contributions will be most significant. We also believe that making these correspondences explicit in a systematic fashion provides evidence that the Agency is pursuing and achieving its stated goals. Of course, to remain valuable for this purpose the Strategic Plan must be updated sufficiently regularly to reflect current priorities in astronomy and astrophysics.

As a procedural comment, not all proposers provided explicit identification of their aims with those of the Strategic Plan, so this innovation was not an unmitigated success in the first try. If this process is to be continued, the instructions to the proposers should provide more emphasis on the need to identify the relationship of the future activities to the Strategic Plan.

5. Length of Proposals

The panel finds that the present 30 page limit is longer than necessary, providing an unneeded burden both on proposers, who feel compelled to use every inch of the maximum limit, and reviewers. We believe that a 20 page proposal limit together with the oral briefing, would provide adequate opportunity for proposers to highlight their achievements, justify their requests for mission extensions, and explain their budget requests.

Mission Assessments

ASCA

Science Strengths

The ASCA mission is an imaging spectroscopic telescope with large collecting area that combines the first use of CCD spectrometers with focusing optics. ASCA is capable of addressing a broad range of science topics that include many goals of the Space Science Enterprise Strategic Plan and has generated a substantial user community. Since the last Senior Review, science achievements include detailed surveys of the ASCA archives to compare line profiles and time variations of the Fe K-alpha line. These studies confirm the relativistic accretion disk origin of the line for a variety of AGN and indicate a dependence of the profile on luminosity, an “X-ray Baldwin” effect.

The continuing importance of ASCA is demonstrated by the use of ASCA spectra by many proposers to plan observations for AXAF in its first observing cycle. As a mature mission ASCA can now afford to carry out long observations that will allow, for example, further monitoring of the Fe K-alpha line from AGN and long-term variability studies. The ASCA project has participated in a vigorous education and public outreach program.

Science Weaknesses

In spite of the fact that the mission is in its sixth year, calibration problems at low energies persist. Results from the CCD spectrometers, SIS1 and SIS2 are not mutually consistent and their performance continues to degrade. The calibration problems, in addition to the modest energy resolution, lead to concerns that the interpretation of low-energy spectral features is not reliable. Beyond calibration difficulties, the usefulness of ASCA is limited by its modest angular resolution and the complexity of its point response function.

The resolving power of AXAF will exceed that of ASCA at Fe K-alpha with a collecting power equivalent to the SIS detectors and will far exceed the spectral resolution at low energies. When AXAF operates successfully, the best continuing role for ASCA will be large programs and long observations.

Recommendations

ASCA continues to produce interesting science, but the impact of science remaining to be done and the new discovery potential is low. The program should continue at a modest level until the launch of ASTRO-E, now planned for February, 2000, plus six months of overlapping operations.

The Senior Review believes that competition for data analysis grants for new observations through the ADP program is appropriate (see general recommendation #2). Though not all observers are successful in obtaining grants in this fashion, in the most recent ADP review, ASCA (and ROSAT) proposals for observing grants (Type B) had a higher success rate than archival proposals (Type A).

Compton Gamma Ray Observatory (CGRO)

Science Strengths

Launched in 1991, the CGRO continues to provide unique observations of energetic photon emissions between 30 keV and 30 GeV. With the exception of EGRET, which has almost exhausted its detector gas, CGRO instruments remain healthy and productive.

Recent discoveries include the "galactic annihilation fountain," a young SNR discovered in the 44Ti line, a possible planetary companion to the Geminga pulsar, the discovery of new soft gamma ray repeaters, and new constraints on the energy content of ions in solar flares. During the mission lifetime, CGRO has provided vital new information on the characteristics of gamma-ray bursts, and continues to be important as a trigger for follow-up observations. Reboost maneuvers in 1993 and 1997 ensure that CGRO could operate for many more years. CGRO will be an important observational tool during the upcoming solar maximum, and will complement HESSI and ACE. The CGRO project has maintained a vigorous education and public outreach program.

Science Weaknesses

EGRET utilization must be severely limited due to the dwindling gas supply. Although BATSE is detecting many gamma-ray bursts, the large error boxes hinder counterpart detection. Except for solar observations, the potential for new discoveries is diminishing. The cost of Science Center functions and Mission Operations is high relative to other missions in an extended phase. The FTOOLS software retrofit has been slow.

Recommendation

As a mature instrument in an extended mission phase, the CGRO must now look for ways to streamline and further automate Mission Operations and Science Center functions. We endorse the continued use of BATSE as an all-sky monitor for transients.

Particularly important are the Gamma Ray Bursts. BATSE can serve as a trigger for the RXTE and ground-based instruments until HETE-2 is launched. Support of Target-of-Opportunity observing of solar flares is also important with the full suite of instruments, particularly when HESSI and ACE are flying. We strongly urge the Science Support Center to complete the FTOOLS software retrofit by the end of 1999 to allow users to access the CGRO data archive. Finally, the panel recommends that Guest Observers should compete for grant support for analysis of CGRO observations within the ADP beginning in 1999.

EUVE

Science Strengths

EUVE provides unique access to the EUV band, with moderate resolution spectroscopy of a wide variety of objects contributing to study of planets and cometary atmospheres, coronae of binaries and single stars including neutron stars, accreting objects, the interstellar medium and possible detection of previously unrecognized diffuse cluster emission.

EUVE is well calibrated, has no loss of capabilities and remains oversubscribed.

The EUVE project has an outstanding record of streamlining mission operations, leading the development of innovative, flexible, and inexpensive satellite operations. Outsourcing the responsibility of EUVE to UC Berkeley successfully demonstrated a new mode of mission operations including science management, proposal selection and grant awards. The EUVE team has maintained an exemplary education and outreach program.

Science Weaknesses

The potential for new discoveries for this mature mission is low. The anticipated future scientific program was deemed not as compelling as that of other missions for FY 01/02. It is anticipated that the satellite will re-enter during 2001.

Recommendations

The last years of operation will provide an opportunity for cross-calibration of EUVE with the AXAF grating spectrometers (HETGS and LETGS) and participation in the Emission Line Project for atomic physics. This joint calibration project is of highest priority. Remaining time should be used for block scheduling of large programs. Operation beyond FY 00 is not recommended.

ISO

Science Strengths

The ESA Infrared Space Observatory, launched in November 1995, completed its data acquisition phase in April 1998. ISO was the first flexible infrared observatory in space, providing large improvements in angular resolution and spectral resolution, and several orders of magnitude improvement in sensitivity over previous space astronomy capabilities. ISO was a “pathfinder” observatory which broke new scientific ground for future infrared observatories such as SIRTF, SOFIA and NGST.

The ISO mission has addressed many aspects of the NASA Strategic Plan, including the formation of stars and planetary systems, the formation and evolution of galaxies, the physics and chemistry of the interstellar medium, and many other topics. In addition to a rich legacy of expected results, the ISO mission has produced many surprises. ISO has identified oxygen in a variety of forms including water ice and vapor. These and many other scientific results will impact most areas of astronomical research from solar system studies to cosmology.

Though the data acquisition phase of the ISO mission is over, much work remains in data reduction, analysis and archiving. The complex on-orbit behavior of the ISO detectors has made the calibration process difficult. The ISO team continues to improve the pipeline processing and calibration of the science data.

The ISO archives promise to be of great value to the entire astronomical community for many years to come. The high-resolution spectra produced by this mission will remain unique for a long time, and will serve as pathfinders for SOFIA and SIRTF.

The ISO mission has been used by and influenced the research of a large group of US astronomers. US participation in the openly competed time available through the guest investigator program has been very high.

Science Weaknesses

Preparation of data for scientific analysis has been hampered by the complexity of data and software, and by calibration difficulties. Even though data acquisition started years ago, the data are not yet available to the general community of scientists.

Recommendations

The high quality and importance of ISO observations justifies support for completion of the data reduction and preparation of a high-quality archive by April, 1999 in order to enable access to ISO data in time for the next ADP proposal cycle. Research funding support by the Project should be directed primarily to the new (previously unfunded) Guest observations (e.g., polarization investigations) conducted during the last few months of ISO operations.

ROSAT

Science Strengths

The ROSAT mission has been an unqualified success. It has opened up X-ray astronomy to a broad user base and made major discoveries in many areas that are of fundamental importance to the astrophysics community in general, and to the NASA Space Science Strategic Plan in particular. Its High Resolution Imager (HRI) still provides a valuable capability - similar to the AXAF High Resolution Camera in terms of field-of-view and sensitivity in the soft X-ray regime. Requests to use the HRI continue to oversubscribe the available observing time.

The ROSAT data archive is an invaluable resource both in its own right, and as a pathfinder for the major X-ray missions to come. The value of the archive can be enhanced by an improved determination of the energy-dependent effective area of the now-defunct PSPC. This instrument provided a much larger field-of-view than AXAF and better sensitivity at low energies (0.1 to 0.3

keV). The ROSAT project has participated in a vigorous education and public outreach program.

Science Weaknesses

With the planned launches of AXAF and XMM in 1999 and ASTRO-E in early 2000, the landscape of X-ray astronomy will radically change during the funding period under consideration. The “uniqueness space” for the existing ROSAT facility will all but vanish, since it will be inferior to AXAF in angular resolution, will provide no spectroscopic capability, will be far inferior to XMM in sensitivity, and will operate only in the soft X-ray band below 2 keV. The recent loss of the remaining spacecraft star tracker and the uncertainty about the efficacy of the attempted work-around using the WFC tracker is a concern, since even success may still lead to a significant degradation in the accuracy of the attitude reconstruction. The Senior Review regrets the continued lack of community access to the ROSAT all-sky survey data.

Recommendation

Even in the era of new X-ray astronomy missions, there is still a good case for the relatively modest investment needed to keep ROSAT operating through the end of 1999, in support of the current plan for Germany to operate ROSAT until 12/99 (assuming success in the efforts to use the WFC in place of the star tracker). The ROSAT team and its user community should continue their efforts to identify specific scientific niches, e.g. mapping of large targets, synoptic observations requiring good angular resolution, and high-risk/high-return programs. The effort to maximize the long-term scientific utility of the archive is especially important.

RXTE

Science Strengths

RXTE promises to produce new and exciting results in the study of compact objects. Recent results include the first tests of strong gravity, discovery of kilohertz x-ray QPO's, the discovery of millisecond X-ray pulsars, constraints on the parameters and equation of state for neutron stars, the discovery of a “magnetar”, detection of new superorbital periods in x-ray binaries and investigation of the variability and spectra of AGN.

Broad energy coverage and excellent time resolution combined with large collecting area makes it possible to investigate the variability of sources on short time scales. The All Sky Monitor provides rapid notification of new transients and long term light curves. RXTE has rapid response time to transients and Gamma Ray bursts. Recent improvements in background determinations have enabled the study of weak sources. The publication rate for XTE-based observations continues to grow. Education and outreach efforts are excellent.

Science Weakness

XTE addresses a very interesting set of phenomena, but has the active participation of only a small portion of the community.

Recommendations

Although operations and science center costs have been reduced, the team should seek further efficiency improvements. Since XTE has completed its prime mission phase, Guest Observer funds should be transferred to the ADP.

VSOP

Science Strengths

The VSOP mission provides the first true space VLBI instrument.

Launched in early 1997, the VSOP commenced full scientific operation in early 1998. The VSOP mission is to be congratulated on this difficult technical achievement, which paves the way for future, sensitive space VLBI missions.

The VSOP is designed to study the Compton limit to radio source brightness, superluminal sources, AGNs, galactic masers, and the interstellar medium.

Science Weakness

The Space VLBI program addresses a narrow range of science problems. The loss of the 22 GHz receiver further severely limits the science potential of this mission. It is not clear that its factor-of-three improvement in spatial resolution relative to the ground-based network alone will result in dramatically new scientific insights. The cost-effectiveness of this mission is very low, as reflected by the low relative ranking.

Recommendation

As with all other missions reviewed here, the Senior Review considered the total NASA Office of Space Science mission operations and data analysis cost of this mission. The Senior Review recommends continued mission support through FY00, and recommends providing grant support only for Principal Investigators at FFRDCs who require salary support. However, no mission support should be assigned beyond FY00, pending demonstration to the next Senior Review of high-quality science performance in comparison with other missions.

Wide-Field Infrared Explorer (WIRE)

Science Strengths

WIRE, the Wide-Field Infrared Explorer, is designed to carry out several deep photometric surveys at wavelengths of 12 and 25 microns to reveal the history of the star formation rate out to redshifts ~1, and to find dusty luminous galaxies to z~3.   Such measurements in the infrared are now critically important for enhancing our understanding of galaxy evolution, a major objective in the

NASA OSS Strategic Plan.

WIRE will provide deep mid-infrared surveys of a substantial sky area, along with redshift measurements from ground-based instruments, allowing systematic study of the evolution of the rate of star-formation in dusty young galaxies. WIRE will not only do a well-focused and important prime science program, dramatically improving on prior measurements with IRAS and ISO, it will also be an important precursor mission for SIRTF, providing rich new material for follow-up studies.

WIRE will be the first cryogenic payload on a SMEX mission, paving the way for future missions requiring such technology. The WIRE team has done an outstanding job of preparing for flight, producing a payload which exceeds performance specifications within the originally proposed cost and a spacecraft well under the proposed cost, all accomplished on schedule. The data processing pipeline was completed before launch, and the team has done a notable job of acquiring necessary correlative data from ISO observations and arranging for ground-based facilities to carry out the imaging and redshift measurements they will need.

Science Weaknesses

The short cryogenic lifetime allows little time to deal with unexpected problems in flight and still meet the observational objectives, an obvious risk factor for the mission.

Interpretation of the survey data in terms of evolution in the star formation rate will be complicated by the lack of direct knowledge of the mid-infrared spectral energy distribution of galaxies at high redshift, e.g., of whether the polycyclic aromatic hydrocarbon (PAH) features are as prominent as they are in local galaxies. The mission team has also just been informed of a change in their launch manifest, delaying the launch by about 7 months. This leaves a barely adequate schedule for producing a high quality WIRE archive in time for the first round of GO proposals for SIRTF.

Recommendation

The 1998 Senior Review ranks the WIRE mission extension number one in terms of likely scientific productivity relative to the investment of NASA MO&DA funds. The importance of the scientific aims of the mission and of its data set for future missions make it imperative to complete the processing and archiving of high quality data products within a year of the end of observations, in time for the first cycle of SIRTF General Observer proposals.

This support will also permit completion of the prime science objectives and very interesting ancillary science objectives of the mission.

Mission Ranking for 1999-2000 (1 is best)

WIRE	1
RXTE	2
ISO	3
CGRO	4
ROSAT	5
ASCA	6
EUVE	7
VSOP	8

Mission Ranking for 2001-2002 (1 is best)

WIRE	1 (tie)
RXTE	1 (tie)
CGRO	3
ASCA	4